that is overlaid on top of real-world content. The real-world content may be viewed directly by a user through a transparent portion of an optical system. The optical system may be used to route images from one or more pixel arrays or a scanning device in a display system to the eyes of a viewer. A waveguide such as a thin planar waveguide formed from one or more sheets of transparent material such as glass or plastic or other light guide may be included in the optical system to convey image light from the pixel arrays to the viewer.

**[0025]** The illumination system may include a light source that supplies illumination for the display. The illuminated display produces image light. An input optical coupler may be used to couple light from the light source into a waveguide in the illumination system. An output optical coupler may be used to couple display illumination out of the waveguide. Input and output couplers may also be used to couple image light from the display into a waveguide in the optical system and to couple the image light out of the waveguide for viewing by the viewer.

**[0026]** The input and output couplers for the head-mounted device may form structures such as Bragg gratings, prisms, angled transparent structures, and/or lenses that couple light into the waveguide and that couple light out of the waveguide. Input and output optical couplers may be formed from diffractive couplers such as volume holograms, other holographic coupling elements, or other diffractive coupling structures. The input and output couplers may, for example, be formed from thin or thick layers of photopolymers and/or other optical coupler structures in which holographic patterns are recorded using lasers. In some configurations, optical couplers may be formed from dynamically adjustable devices such as liquid crystal components (e.g., tunable liquid crystal gratings, polymer dispersed liquid crystal devices), or other adjustable optical couplers.

**[0027]** A schematic diagram of an illustrative head-mounted device is shown in FIG. **1**. As shown in FIG. **1**, head-mounted device **10** may have control circuitry **12**. Control circuitry **12** may include storage and processing circuitry for controlling the operation of head-mounted display **10**. Circuitry **12** may include storage such as hard disk drive storage, nonvolatile memory (e.g., electrically-programmable-read-only memory configured to form a solid state drive), volatile memory (e.g., static or dynamic random-access-memory), etc. Processing circuitry in control circuitry **12** may be based on one or more microprocessors, microcontrollers, digital signal processors, baseband processors, power management units, audio chips, graphics processing units, application specific integrated circuits, and other integrated circuits. Software code may be stored on storage in circuitry **12** and run on processing circuitry in circuitry **12** to implement operations for head-mounted display **10** (e.g., data gathering operations, operations involving the adjustment of components using control signals, image rendering operations to produce image content to be displayed for a user, etc.).

**[0028]** Head-mounted device **10** may include input-output circuitry **14**. Input-output circuitry **14** may be used to allow data to be received by head-mounted display **10** from external equipment (e.g., a tethered computer, a portable device such as a handheld device or laptop computer, or other electrical equipment) and to allow a user to provide head-mounted device **10** with user input. Input-output circuitry **14** may also be used to gather information on the environment in which head-mounted device **10** is operating. Output components in circuitry **14** may allow head-mounted device **10** to provide a user with output and may be used to communicate with external electrical equipment.

**[0029]** As shown in FIG. **1**, input-output circuitry **14** may include one or more displays such as display(s) **18**. Display(s) **18** may be used to display images for a user of head-mounted device **10**. Display(s) **18** have pixel array(s) or laser scanning patterns to generate images that are presented to a user through an optical system. The optical system may, if desired, have a transparent portion through which the user (viewer) can observe real-world objects while computer-generated content is overlaid on top of the real-world objects by producing computer-generated images on the display(s) **18**.

**[0030]** Optical components **16** may be used in forming the optical system that presents images to the user. Components **16** may include static components such as waveguides, beam splitter structures embedded in waveguides, static optical couplers, and fixed lenses. Components **16** may also include adjustable optical components such as an adjustable polarizer, tunable lenses (e.g., liquid crystal tunable lenses, tunable lenses based on electrooptic materials, tunable liquid lenses, or other tunable lenses), a dynamically adjustable coupler (e.g., an adjustable MEMs grating or other coupler), an adjustable liquid crystal holographic coupler such as an adjustable liquid crystal Bragg grating coupler, adjustable holographic couplers (e.g., electro-optical devices such as tunable Bragg grating couplers, polymer dispersed liquid crystal devices, etc.), couplers, lenses, and other optical devices formed from electro-optical materials (e.g., lithium niobate or other materials exhibiting the electro-optic effect), or other static and/or tunable optical components. Components **16** may be used in proving light to display(s) **18** to illuminate display(s) **18** and in may be used in providing images from display(s) **18** to a user for viewing. In some configurations, one or more of components **16** may be stacked, so that light passes through multiple components in series. In other configurations, components may be spread out laterally (e.g., multiple displays may be arranged on a waveguide or set of waveguides using a tiled set of laterally adjacent couplers). Configurations may also be used in which both tiling and stacking are present.

**[0031]** Input-output circuitry **14** may include components such as input-output devices **22** for gathering data and user input and for supplying a user with output. Devices **22** may include sensors **26**, audio components **24**, and other components for gathering input from a user or the environment surrounding device **10** and for providing output to a user. Devices **22** may, for example, include keyboards, buttons, joysticks, touch sensors for trackpads and other touch sensitive input devices, cameras, light-emitting diodes, and/or other input-output components.

**[0032]** Cameras or other devices in input-output circuitry **14** may face a user's eyes and may track a user's gaze. Sensors **26** may include position and motion sensors (e.g., compasses, gyroscopes, accelerometers, and/or other devices for monitoring the location, orientation, and movement of head-mounted display **10**, satellite navigation system circuitry such as Global Positioning System circuitry for monitoring user location, etc.). Using sensors **26**, for example, control circuitry **12** can monitor the current direction in which a user's head is oriented relative to the